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EVALUATION OF AIR POLLUTION EFFECTS IN THE SOUTH

The purpose of this report is to document work which has been done toward implementing the Southeastern Area, Environmental Protection and Improvement Unit, Air Pollution Program during the period of July 1, 1973 - September 30, 1974. This Unit program has involved SA personnel from both the Environmental Quality Evaluation and Forest Pest Management Groups, as well as personnel from State and other Federal organizations. Robert C. Loomis has been responsible for overall program leadership. Other participants have been Dr. William H. Sites and Melvyn J. Weiss.

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INTRODUCTION

The U.S. Forest Service, Forest Pest Management Group, has the basic responsibility of cooperatively protecting and preserving the forest resource through the prevention, detection, evaluation, and suppression of injurious forest pests. The effects of air pollution are considered to be an abiotic disease problem and thereby fall within Forest Pest Management's cooperative detection and evaluation responsibility. Unlike the procedure for most other pest problems, the U.S. Forest Service or cooperating State Forestry agencies have no responsibility for prevention or suppression of the causal agent - air pollution emissions. Other State and Federal agencies have this responsibility and need information about air pollution effects to plants within their respective areas of responsibility. If significant plant injury is consistently noted, a modification of control strategy may be warranted. Forest Pest Management's role is to provide technical assistance, to participate, and to encourage others to participate, in the detection and evaluation of air pollution-caused effects to trees in forest stands and urban areas.

Program responsibilities and direction are authorized as follows:

1. Chief's Program of Work FY 1975 - Gives direction to develop capability to evaluate air pollution damage to trees in forest stands and urban areas.

2. Forest Pest Control Act 1947 - Provides for the prevention, detection, evaluation, and suppression of injurious forest pests in order to protect and preserve the forest resource.

3. National Environmental Policy Act, as amended, 1969 - Provides for the preparation and review of environmental impact statements. The Forest Service is listed as the Federal agency with jurisdiction by law or special expertise to comment on air quality and air pollution control impacts on the forest resource (Federal Register, May 2, 1973, p. 10861).

4. Clean Air Act as amended, 1973 - Provides for air pollution control research, for establishing air quality standards, for financial support to State and local Air Pollution Control agencies, and for development of regional air pollution control programs in order to protect and enhance the nation's air resource. Forest Service has implied technical support responsibility.

General Air Pollution Status in the United States

Injury to vegetation by phytotoxic levels of sulfur dioxide, fluoride, and other pollutants has been recognized for many years. Various reports have shown much of the injury has been associated with industrial processes such as electricity generation; petroleum and natural gas production and refining; ore smelting and refining; and phosphate fertilizer

production (2, 5, 10, 11). At times, injury to vegetation from these point sources has been severe with symptoms of injury to sensitive vegetation being noted 15 - 30 miles from the source. The most severe plant injury has usually occurred in the vicinity of large sources without adequate emission control, or in areas where meteorological or topographical conditions hindered pollutant dispersion. In most other cases, obvious foliage injury has been limited to within 10 miles of the source.

The threat to vegetation from oxidants, particularly ozone, is of more recent concern (20). This pollutant occurs naturally and is also a product of photochemical reaction of automobile exhaust in the atmosphere. Whereas pollution-caused effects to vegetation from most point sources usually occur in a relatively limited area, ozone has caused effects over wide areas. For example, in California, ozone and related pollutants have caused severe injury to forests and crops as much as 80 - 100 miles from Los Angeles (14, 17). In the East, widespread white pine tipburn and chlorotic dwarf disease have been attributed to ozone, and to ozone in combination with other pollutants (3, 4, 6). The scientific debate continues about the origin of ozone in many areas. Some studies suggest that high rural ozone levels are due to the transport of ozone and ozone precursors from urban areas (18, 19). Other studies suggest that natural phenomena such as photochemical generation from naturally occurring precursors or transport of ozone from the stratosphere are the sources (21, 23). Both probably contribute, but the proportion of urban produced ozone versus naturally produced ozone has yet to be determined. Also, there is some question if naturally produced ozone ever attains levels high enough to cause severe plant injury over large areas. One rather perplexing issue is that needle-blighted white pine trees have been reported since 1922 (7, 15, 24, 26, 29). While the cause of the blight was not determined, no infectious pathogen was found. Later ozone or ozone in combination with other pollutants was suggested to be the likely cause of what appears to be either the same or a very similar problem.

Attempts have been made in California, Pennsylvania, and New Jersey to determine the economic effects of air pollution (8, 13, 16, 30). These were field surveys in which State Extension personnel either diagnosed injury and estimated loss, or reported suspect areas for evaluation by plant pathologists. No standard evaluation procedure was used for all surveys and methods of assessing loss varied. Estimating loss to commercial crops proved difficult even though some data was available concerning crop value and expected value loss due to air pollution effects. This information is not available for much of the forest and tree resource. For example, no standard method has been devised for estimating loss to noncommercial forest stands, watershed areas, roadside plantings, ornamental and urban trees, and park vegetation. Even for commercial stands where tree values are known, there is little information concerning value loss due to air pollution effects, unless trees are actually killed.

Another approach was developed by the Stanford Research Institute under contract by the Coordinating Research Council and the Environmental

Protection Agency (1, 2). A model for estimating dollar losses to vegetation resulting from air pollution effects was developed. This technique consisted of the following steps:

1. Determine the location by county of potential plant-damaging concentrations of ozone, PAN, oxides of nitrogen, sulfur dioxide, and hydrogen fluoride, as indicated by sources of hydrocarbons, oxides of nitrogen, sulfur dioxide, and hydrogen fluoride. The survey was limited to these pollutants because they are thought to cause approximately 90 percent of the injury.

2. Estimate the relative concentration of plant-damaging pollution potential of the above pollutants in these counties, based on the amount of emissions of the sources into the atmosphere and the capabilities of meteorological conditions to concentrate them.

3. Determine the dollar value of crops and ornamentals in the pollution-threatened county.

4. Based on their relative sensitivity, determine the percentage loss to each crop and ornamental that is likely to occur under different plant-damaging pollution potentials calculated in No. 2, above.

5. Multiply, in each county, the value of each crop by the percentage of loss expected under the pollution conditions in each county for each pollutant. Then integrate individual crop losses into a total for the county; then sum county values for State, region, and country.

It should be recognized that even though various model inputs are based on documented material, assumptions still had to be made where information was lacking. For example, research and survey data obtained in one part of the country was applied to areas where no such data existed. Thus, the final loss estimates are theoretical and have yet to be verified by field examination. Estimates derived by this method are in general agreement with the California and New Jersey surveys, but differ more in the Pennsylvania and New England surveys (2). Particular strengths of the model are that estimates are made uniformly and the model can be adjusted as new information becomes available. Some results of these surveys are presented in Table 1 and 2.

The actual dollar figures in these air pollution damaged plant surveys should be interpreted with care. For the reasons discussed previously, they represent the best estimate available; however, reliable data has yet to be developed for many areas. Despite these shortcomings, survey work done so far has been helpful and suggests several important points.

1. Oxidant pollution appears to be causing most of the loss.

2. Loss due to air pollution can vary greatly from year to year.

3. Greatest obvious losses are in areas with high value crops or products.

TABLE 1 RESULTS OF SEVERAL AIR POLLUTION PLANT DAMAGE SURVEYS

Survey	Date	% of Total Crop and Ornamental Value Lost	% Loss from Fluoride	% Loss from Sulfur Dioxide	% Loss from Other Pollutants	% Loss from Oxidants
California [16]	1970	12	15	2	15	68
New Jersey [8]	1971	8	2	2	16	80
Pennsylvania [30]	1969	1 - Only direct losses estimated	--	5	10	85
Pennsylvania [13]	1970 1971	< 1 - Only direct losses estimated	--	6	91	3
Stanford Report [2] Nation-Wide	1964	2	3	5	--	92
Stanford Report [2] Nation-Wide	1969	1	4	6	--	90
Stanford Report [2] SA Minus Virginia Plus New Mexico	1969	< 1	19	15	--	66

TABLE 2 STATES IN THE SOUTH WITH LOSSES DUE TO POLLUTION OF OVER ONE MILLION DOLLARS [2]

STATE	ESTIMATED LOSS FROM POLLUTION (Dollars)	ESTIMATED VALUE OF ALL VEGETATION (Dollars)	LOSS AS PERCENT OF TOTAL VALUE
FLORIDA	1,886,500	59,724,600	3.2
TEXAS	1,712,500	156,748,400	1.1
ALABAMA	1,216,600	128,052,000	1.0
TENNESSEE	1,147,000	79,350,000	1.4

General Air Pollution Status in the South

As with other parts of the country, injury to southern vegetation has been reported in the vicinity of such industrial processes as electricity generation; petroleum and natural gas production and refining; ore smelting and refining; and phosphate fertilizer production. Also, there have been reports of oxidant injury to several different plant species including tobacco, potatoes, and white pine. Documentation of this injury has been fragmentary, and little is known about the actual impact of air pollution on vegetation in the South. It was evident after discussions with both State and Federal officials who are involved with air pollution control and related programs, that aside from Tennessee Valley Authority surveys, no systematic effort has been made to determine where air pollution may be affecting vegetation. In addition, the possible effects of oxidant pollution, important in other parts of the country, have yet to be thoroughly investigated in the South.

Figure 1 and Appendix 1, show counties where air pollution may be affecting vegetation. Counties where trees have been examined in the course of our air pollution activities are also shown. These counties were identified from:

1. Stanford Research Institute Reports (1, 2).

2. Previous surveys or reports.

3. Discussion with State and Federal air pollution control officials.

PROCEDURE

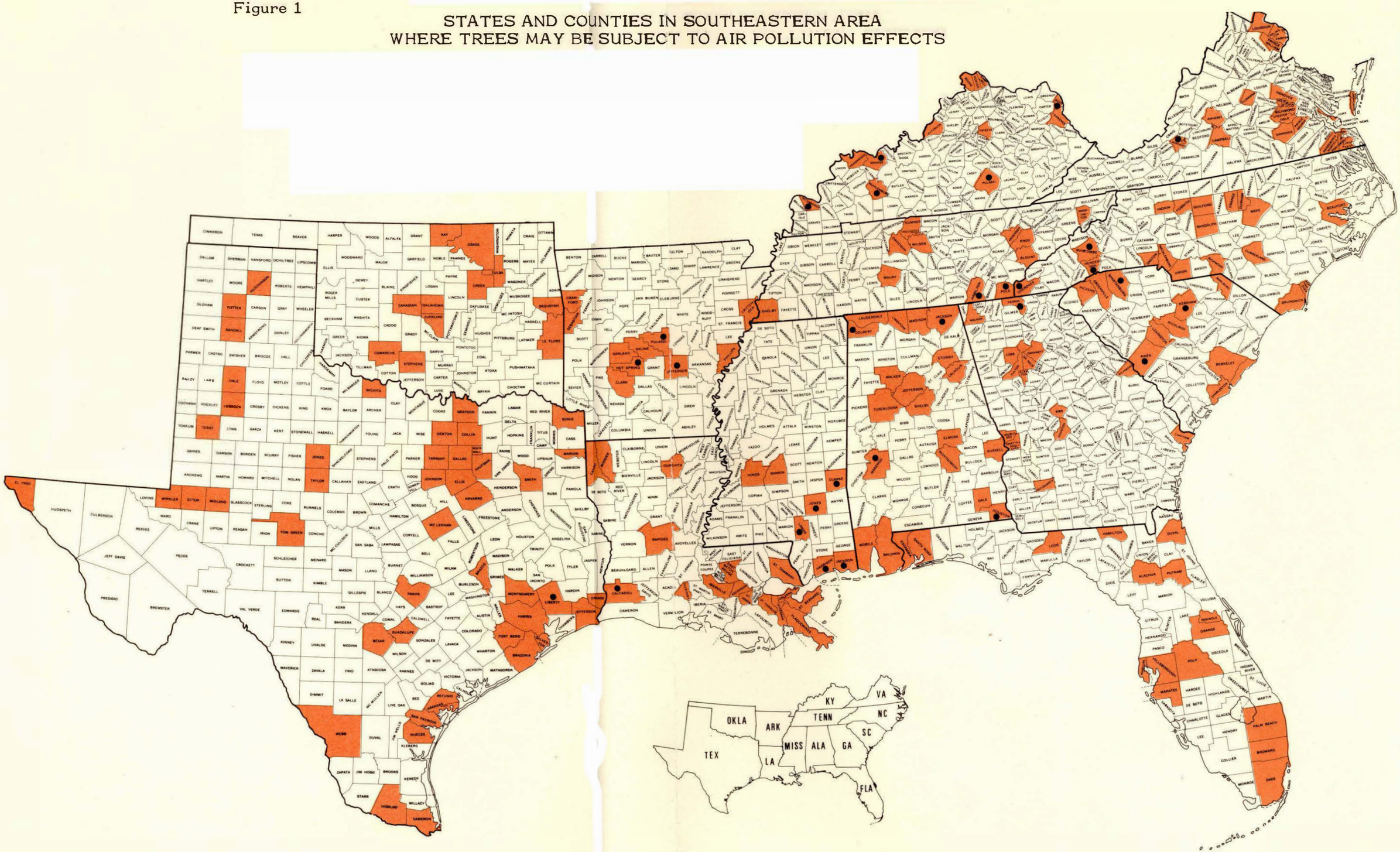
Air Pollution Evaluation

Detecting and evaluating the effects of air pollution can be difficult; however, certain basic evaluation procedures have been developed which increase the reliability and confidence in a particular diagnosis. Pollutants such as sulfur dioxide or fluorides may cause characteristic symptoms on trees and associated plants. This also increases confidence in a diagnosis where these pollutants are suspect. Conversely, the symptomatology of other pollutants including ozone are less distinguishable, particularly with regard to forest species. In these cases, symptoms of air pollution-caused injury can closely resemble and be easily confused with symptoms of other causal agents. Many factors influence the expression of air pollution damage to plants (9, 12).

An air pollution evaluation work plan was developed by Environmental Protection and Improvement plant pathologists which was based on program needs and accepted survey procedures (Appendix 2). Several refinements and improvements have been made since the plan was first implemented.

Figure 1

STATES AND COUNTIES IN SOUTHEASTERN AREA WHERE TREES MAY BE SUBJECT TO AIR POLLUTION EFFECTS



■ - County with air pollution effect potential.

● - County in which trees were examined by EPI Plant Pathologist.

Cooperating State and Federal agencies which have air pollution control, evaluation, or research responsibilities are listed below. These agencies were consulted while developing both the overall program and the evaluation work plan.

State - State Forestry
State Air Pollution Control
State Extension

Federal - Forest Service
Tennessee Valley Authority
Environmental Protection Agency
Agricultural Research Service

Program Implementation

The first priority was to establish an air pollution program which was responsive to the Chief's FY 75 Program of Work; the Forest Pest Control Act; the National Environmental Policy Act; and the Clean Air Act. The program effort has been aimed at four activities:

1. Defining the current problem.

2. Developing standard survey and evaluation procedures.

3. Encouraging cooperative detection and evaluation surveys.

4. Providing specialized technical assistance to State and other Federal agencies.

These four activities are all aimed at the broader long range objectives of 1) determining, in cooperation with others, what the impact of air pollution is on trees in forest stands and urban areas; and 2) detecting changes in the extent and severity of air pollution effects to trees in the South.

The first step in defining where and how air pollution is affecting trees was to review the literature and to contact various State and Federal agencies with air pollution control, evaluation, or research responsibility. These meetings provided an opportunity to locate and discuss air pollution problem areas which previous workers and State and Federal officials believed to be important. They also provided the opportunity to discuss our respective program and evaluation needs, and to meet the individuals working with these agencies. The discussions were helpful in developing our program to fit the needs of individual States. In several instances, cooperative field investigations were undertaken as a result of meetings with State Forestry or Air Pollution Control organizations.

Standard survey and evaluation procedures are needed to insure efficient use of time, proper data collection, and achievement of desired results. Basic survey procedures have been developed by other scientists but

adaptions were made to meet specific program needs. As needs change, survey and evaluation procedures can be modified.

Cooperative surveys are the means by which air pollution effects to vegetation can best be detected and evaluated. Several State and Federal Agencies have air pollution responsibilities and are involved with various aspects of air pollution evaluation. Each can make their particular contribution to the survey process. Thus, through cooperative action significant progress can be made in determining where air pollution is affecting trees in the South.

The specialized technical assistance provided by the Forest Pest Management Group to other Federal and State Agencies is related to the detection and evaluation of air pollution effects to trees and associated forest vegetation. The main thrust of this activity is to provide assistance for evaluations, training, or program development. The procedure being followed is to provide basic training for State biologists, pathologists, or entomologists. If field assistance is needed, support is available in the Area Office and in both the Alexandria and Asheville Field Offices. If a particular problem is beyond our capability, or if an outside opinion is desired, several individuals expert in the effects of air pollution on plants have agreed to assist.

The long range objectives of determining air pollution impact on trees in the South and of detecting changes in the extent and severity of air pollution effects to trees will not be accomplished through Forest Service efforts alone. Because of Forest Service cooperative responsibility to protect the forest resource from injurious pests, the Forest Pest Management Group must contribute leadership, technical information, and expertise to accomplishing these objectives. Ultimately, coordinated participation will be needed from scientists in other government agencies, universities, and industries.

RESULTS

A compilation of air pollution program related activities of personnel in the Environmental Protection and Improvement Unit are presented in this section. These activities include Federal and State Agency coordination contacts, technical assistance trips, cooperative surveys, talks and papers presented, publications, and training.

State and U.S.F.S. National Forest Contacts

ALABAMA

Contacts - Alabama Forestry Commission
James Hyland, Entomologist

Alabama Division of Air Pollution Control
James W. Cooper, Director
Susan Robertson, Engineer
Cherie Williams, Biologist

Reference - Pierce's 3400 memo, dated 7/3/74

Summary of Work - During May 1974, Loomis and Weiss met with Jim Hyland in Montgomery to discuss the air pollution program. It was learned that Hyland had previously been involved with air pollution matters in that he represents the State Forester at the Air Pollution Control Commission meetings. In that capacity he had met with members of the Division of Air Pollution Control concerning the evaluation of injury to trees. That afternoon, Hyland, Weiss, and Loomis met with James Cooper and Susan Robertson to discuss our respective programs, particularly the services each agency provides. In this regard Cooper mentioned that he would be interested in air pollution survey results and that he would supply information he had concerning emission sources or monitoring data. Also, he expressed a desire to have Cherie Williams, the Air Pollution Control Division's biologist, participate when possible.

In June 1974, Cherie Williams had been involved with examining vegetation near two souces of air pollution in Houston and Marengo Counties. A cooperative trip to examine these areas was made by Williams, Hyland, Weiss, and Loomis. Symptoms of typical fluoride effects were noted on several forest species including redbud, sweetgum, loblolly pine, blackberry, and sumac.

Future Work - In FY 75, further explore the possibility of 1) taking aerial photographs of several problem areas, and 2) participating in a cooperative survey.

ARKANSAS

Contacts - Arkansas Forestry Commission
Bill Hoffard, Entomologist
Dick Deed, Forester

Arkansas Department of Pollution Control and Ecology
S. Ladd Davies, Director
Jarrell Southall, Chief, Air Division
Trusten Holder, Chief, Environmental Preservation
John Mitchell, Chemist
Roger Morris, I&E Specialist

Reference - Pierce's 3400 memo, dated 7/15/74
Pierce's 1380 memo, dated 8/26/74

Summary of Work - During July 1974, several telephone discussions were held between Southall, Holder, Weiss, and Loomis concerning air pollution

effects and the possibility of injury to pine trees by acidic precipitation. The Department of Pollution Control and Ecology had conducted a hearing concerning a proposed coal-fired power plant near Redfield, Arkansas, and this subject was discussed. Little has been published in this country concerning acid rain and a definitive conclusion about this potential hazard was not reached.

In August 1974, Hoffard, Buffam, and Loomis examined vegetation reportedly affected by emissions from a chemical pesticide plant in Pulaski County. Some tree mortality, decline, and foliage symptoms were noted. Hoffard requested that we provide aerial photographic coverage of the affected area.

During this same trip, Weiss, Buffam, and Loomis met with representatives of the Arkansas Forestry Commission and the Department of Air Pollution Control and Ecology in Little Rock. Again, the possible effects of acidic precipitation on pine trees was discussed. In addition, two sources which might be affecting Federal land were identified in Garland and Crawford Counties. We visited the immediate vicinity of the aluminum reduction plant in Garland County and observed possible air pollution effects on loblolly pine and other forest species including blackberry, sumac, poison ivy, oak, and hickory.

Future Work - A cooperative survey of the State was tentatively scheduled with Hoffard for summer 1975. The aerial photographs of the affected area in Pulaski County will also be taken at that time.

FLORIDA

Contacts - Florida Division of Forestry
Charles Chellman, Entomologist

Florida Department of Pollution Control
Walter E. Starnes, Chief, Air and Solid Waste Planning

Reference - Loomis' 1360 memo, dated 9/3/74

Summary of Work - In March 1974, Loomis met with representatives of the Florida Division of Forestry and the Department of Pollution Control in Tallahassee. One purpose of the visit was to explain the Forest Service Environmental Protection and Improvement Unit Air Pollution Program and to encourage cooperative participation by the State Forestry and Air Pollution Control organizations in the detection and evaluation of air pollution effects on trees in forest and urban areas.

Another purpose of the visit was to identify particular areas of the State where air pollution may be affecting trees. According to a State Report, Pinellas, Polk, and Hillsborough appear to have the worst air pollution problems. National Forest land may be affected by a fluoride source in Hamilton County.

Future Work - The possibility of participating in a cooperative survey with the Florida Division of Forestry is being explored for the summer of 1975.

GEORGIA

Contacts - Georgia Air Quality Control Section
Robert Collom, Section Chief
Rafael A. Ballagas, Pollution Control Specialist
Tom Hughes, Biologist

Reference - Loomis' 1360 memo, dated 8/6/74
Hughes' memo, dated 8/16/74

Summary of Work - In August 1974, Loomis and Abrahamson met in Atlanta with representatives of the Air Quality Control Section to discuss our Air Pollution Program. Later, Loomis, Abrahamson, and Hughes examined an area near Douglasville in response to a report of possible air pollution or herbicide injury. The injury was probably caused by a severe hail storm which occurred in late June. On the way back to Atlanta, the effects of herbicide injury were noted on loblolly pine along Interstate Highway 75, north of Atlanta.

During this trip, Hughes mentioned that he examines air pollution-injured vegetation, and would like to participate in any cooperative survey of air pollution problem areas which might be undertaken.

Future work - Identification of problem areas, State Forestry contacts, and cooperative surveys, FY 75 and 76.

KENTUCKY

Contacts - Kentucky Division of Forestry
Harry Nadler, State Forester
Mark Matuszewski, Pathologist

Kentucky Division of Air Pollution
John Smither, Director
Bill Gatewood, Chief, Air Pollution Engineering
Roger Blair, Chief, AP Enforcement & Surveillance
Hisham Sa'aid, Chief, Technical Services

U.S. Forest Service, Daniel Boone National Forest
Joe Bennett, Assistant Timber Staff
Jack Steelmon, District Ranger, Somerset RD

Reference - Abrahamson's and Loomis' 7400 memo, dated 11/6/73
Yasinski's 3410 memo, dated 3/21/74

Summary of Work - During October 1973, Loomis and Phelps met with Harry Nadler in Frankfort to discuss the Air Pollution Program.

Also in October 1973, Loomis, Abrahamson, and Phelps met with Mark Matuszewski and the Director and Staff of the Division of Air Pollution. The Environmental Protection and Improvement Unit Air Pollution Program was discussed. Other topics of discussion were: 1) the relationship of the SA, S&PF, and the State Forestry organization, 2) the roles of S&PF and State Forestry in evaluation of air pollution injury to trees, 3) opportunities for cooperative effort, and 4) assistance the Division of Air Pollution could give in locating air pollution problem areas.

In May 1974, Sites and Loomis met with Matuszewski to plan a cooperative survey of several industrial areas with a potential for air pollution injury to vegetation.

In June and July 1974, a cooperative air pollution survey was conducted by Sites, Matuszewski, and Loomis. The final report is being written.

Future work - Provide technical assistance and follow-up to the survey as needed.

LOUISIANA

Contacts - Louisiana Forestry Commission
Harold LaHaye

Louisiana Air Control Section
G.W. Engelhardt, Section Chief
G. Von Bodungen
H.F. Stegall

Reference - Abrahamson's and Loomis' 1360 memo, dated 1/12/74
Pierce's 1380 memo, dated 7/2/74
Pierce's 1380 memo, dated 7/8/74
Pierce's 1380 memo, dated 8/22/74

Summary of Work - In December 1973, Honing, Abrahamson, and Loomis met in New Orleans with G.W. Engelhardt and members of his staff. Stegall has done some vegetation-injury evaluation, and suggested that the Lake Charles area and the areas surrounding several electric power generating stations would be good for cooperative surveys.

During June 1974, Weiss met separately with Engelhardt and Stegall, and with Harold LaHaye. A trip was scheduled to examine trees in the Lake Charles area.

In August 1974, Weiss, Stegall, and LaHaye examined trees near Lake Charles which were reportedly affected by air pollution. Needle tip necrosis and marginal leaf necrosis on oaks and other hardwoods was noted. The need for trend plots, photo points, and aerial photographs

was discussed; however, no final commitments were made.

Future Work - The possibility of taking aerial photographs and of making a baseline survey of Sam Houston State Park north of Lake Charles has been suggested. Further follow-up is needed in order to schedule this work.

MISSISSIPPI

Contacts - Mississippi Forestry Commission
Richard Collins, Plant Pathologist

Mississippi Division of Air Pollution Control
Jerry Stubberfield, Division Chief

Reference - Loomis' 7400 (1360) memo, dated 1/29/74
Pierce's 1380 memo, dated 7/8/74

Summary of Work - During January 1974, Collins, Loomis, and Pawuk investigated reported air pollution injury in Gulfport. Needle chlorosis and tipburn, crown thinning, premature needle cast, and tree mortality were noted on loblolly pine in an area approximately 2 miles by 1/2 mile. No foliage abnormalities were noted on other tree and plant species. Dr. Glen Snow, Research Plant Pathologist, Southern Forest Experiment Station, originally reported this problem in the spring of 1973. Neither he nor his associates have found any insects or diseases which might be contributing to the loblolly decline.

In June 1974, Weiss met in Gulfport with Collins, Stubberfield, Snow, and Tom Rose of the Environmental Protection Agency office in Athens, Georgia; to review the Gulfport problem. Trees were tagged, photographed, associated vegetation was examined, and foliage samples were collected. As before, it was thought that air pollution might be implicated. However, inconclusive symptomatology and lack of information on pollutants and pollutant levels hindered a positive diagnosis. Several possible cooperative approaches to the problem were discussed with Collins, Stubberfield, and Rose. The final report will be completed by January 1975.

A cooperative survey was conducted in several counties of the State during July 1974. The final report is being written.

Future Work - Provide technical support and survey follow-up as needed.

NORTH CAROLINA

Contacts - Division of Forest Resources
Coleman Doggett, Pest Control Forester

Office of Water and Air Resources
W.E. Knight, Assistant Director
Philip B. Wainwright, Regional Engineer

Reference - Loomis' 7400 memo, dated 8/9/73

Cordell, C.R., W.H. Sites, and E.H. Manchester. 1973. AIR POLLUTION DAMAGE TO SEED ORCHARD WHITE PINE IN WESTERN NORTH CAROLINA. USDA, Forest Service, Southeastern Area, State and Private Forestry, Report No. 74-1-9, 10 pp.

Summary of Work - During July 1973, Loomis and Honing met with W.E. Knight in Raleigh to discuss the Air Pollution Program. Knight encouraged a continuation of air pollution injury detection and evaluation in cooperation with the North Carolina Division of Forest Resources. Other topics of discussion included an air pollution problem near Raleigh; ozone injury to white pine; and a cooperative monitoring station in western North Carolina.

In November 1973, a report entitled "Air Pollution Damage to Seed Orchard White Pine in Western North Carolina" was completed. This report summarized the evaluation of pronounced needle "tip burn" and subsequent tree mortality which occurred annually in three southern Appalachian white pine seed sources at the Beech Creek Seed Orchard in western North Carolina. A survey in 1972 revealed over 900 symptomatic white pines, representing 25 clones or families, in the three seed sources. A 1973 survey revealed over 300 symptomatic trees involving 14 clones within the North Carolina seed source. In addition, 19 percent of the North Carolina white pines surveyed in 1973 were dead. Both tree symptoms and mortality patterns appear to be clonally oriented and highly representative of an air pollutant causal agent. Neither specific pollutant nor source have been identified.

In June 1974, Bill Sites discussed the Air Pollution Program with Coleman Doggett. Particular discussion topics were the air pollution evaluation assistance provided by the Forest Pest Management Group, and the intent of cooperative surveys as outlined in the Evaluation Work Plan.

Future Work - Reestablish contact with both the State Air Pollution and Forestry organizations. (The Air Quality Division has a biologist who is involved with evaluating air pollution effects to vegetation.) In addition, provide technical assistance as needed.

SOUTH CAROLINA

Contacts - South Carolina Commission of Forestry
John E. Graham, Forest Management Assistant
Michael C. Remion, Entomologist

South Carolina Division of Air Pollution Control
W. G. Crosby, Division Chief

Clemson University
Dr. Luther Baxter, Department of Plant Pathology
Dr. Wesley Witcher, Department of Plant Pathology

Reference - Loomis' 7400 memo, dated 9/21/73
Cordell's 3400 memo, dated 5/14/74
June 1974, FOREST PEST STATUS REPORT, Southeastern Area

Summary of Work - During September 1973, and June 1974, Sites, Graham, Witcher, and County Forester Charles Jones examined several areas in Aiken County in response to reports of air pollution injury to elms. It was decided that among other problems, root rot, soil compaction, mechanical wounding, and insects were the most likely contributing factors to this decline. Also in September 1973, Honing, Abrahamson, and Loomis met with officials of the Forestry Commission, the Division of Air Pollution Control, and Clemson University. The purpose of the trip was to explain various Environmental Protection and Improvement Unit programs, particularly air pollution and pesticides. In regard to forest air pollution injury detection and evaluation, it appeared that working relationships were already developing among the Division of Air Pollution Control, the Forestry Commission, the State Extension Service, and the U.S. Forest Service. The Extension plant pathologists at Clemson reaffirmed their availability to lend assistance as needed.

In April 1974, Sites and Graham examined an area in Kershaw County in response to reports of air pollution injury to forest vegetation. No apparent insect or disease activity was found which could cause the decline problem. The location of the trees relative to the source and the symptomatology of vegetation in the area suggests an air pollution problem. Information concerning source emissions and pollutant concentrations are needed in order to make a more definitive diagnosis.

During September 1974, Sites, Graham, and Urban Utilization Forester R.C. Simmons met with an industrial representative in Spartanburg County to determine the cause of hardwood and conifer decline and mortality near a plant site. Hardwoods suffered drought and mechanical injuries, white pine had needle tip burn, and loblolly pine was killed in a one acre spot. Although the causes of the tree mortality decline were not determined, the evidence at the time of the evaluation did not implicate air pollution as the causal agent.

Future Work - Provide additional technical assistance as needed.

TENNESSEE

Contacts - Tennessee Division of Forestry
Max C. Young, State Forester
Hart W. Applegate, Assistant State Forester
Bruce W. Kauffman, Pathologist

Tennessee Division of Air Pollution Control
John W. Walton, Assistant Director
Robert L. Foster, Jr., Chief, Technical Services Section
Jean A. Watson, Biologist

U.S. Forest Service, Cherokee National Forest
Robert Lusk, Forest Supervisor
James Cooper, Timber Staff
Earl Rayburn, Assistant Timber Staff

Cities Service Corporation, Copper Hill
Richard Estes and Bill Mercer, Environmental Protection Unit

Reference - Abrahamson's and Loomis' 7400 (1360) memo, dated 11/6/73
Yasinski's 7400 memo, dated 4/23/74
Loomis' 1360 memo, dated 5/28/74
Thompson's 3400 memo, dated 7/8/74

Summary of Work - During October 1973, Loomis, Abrahamson, and Phelps met with Walton and Foster of the Tennessee Division of Air Pollution Control. Main points of discussion were Environmental Protection and Improvement Unit Air Pollution Programs and the relationship of SA, S&PF with the State Forestry organization. Other topics included the pre-emergence tip-burn problem in white pine; cooperative air pollution surveys; and identification of air pollution problem areas.

Later that morning, the Air Pollution Program was discussed with State Forester Max Young. He expressed a willingness to cooperate in the Air Pollution Program as needed.

In March 1974, Loomis, Sites, Kauffman, and Applegate met to discuss the program and to identify, in cooperation with the Division of Air Pollution Control, existing and potential air pollution problem areas. Jean Watson, Division of Air Pollution Control Biologist, expressed a desire to participate in any cooperative surveys which might be undertaken.

In May 1974, Loomis, Phelps, and Tom Swofford - Forest Service Region 8, Division of Range, Timber and Wildlife - visited Polk County (Copperhill) Tennessee. The purpose was to (a) learn more about Forest Service and Cities Service Corporation efforts to revegetate the area, (b) visit U.S. Forest Service mycorrhizae and air

pollution research study plots, and (c) examine forest vegetation for air pollution effects.

Forest Service people contacted included Lusk, Cooper, Rayburn, and District personnel from the Ocoee and Hiwassee Ranger Districts, Cherokee National Forest. Cities Service Corporation personnel were Estes and Mercier. Symptoms of sulfur dioxide injury were noted on the Ocoee District revegetation project. The Hiwassee District Ranger expressed concern about the tipburn problem on white pine which has been attributed to an air pollutant. Symptoms were not evident at the time of our visit.

In June 1974, Sites, Kauffman, and Harold Cardin visited several areas of the Prentice Cooper State Forest and the Harrison Bay State Park. This trip was in response to a belated report of possible air pollution injury. Virginia pine was reportedly defoliated in March, and by June the trees had produced new foliage. Symptoms of air pollution were not noted at that time.

Future Work - Participate in a cooperative survey in June - July, 1975. Provide technical assistance as needed.

TEXAS

Contacts - Texas Forest Service
Dr. Ronald Billings, Entomologist
Garland Mason, Entomologist
H.A. Pase, Entomologist

Texas Department of Air Pollution
Cecil Bradford, Compliance Division Leader
Dr. Marion Preussee, Monitoring Leader

Texas Agricultural Extension Service, Eastern Center, Overton, Texas
Dwight S. Fate, Extension Forester
Dr. Leon Smith, Plant Pathologist

Reference - Abrahamson's 1360 (7400) memo, dated 10/10/73
Honing's 7400 memo, dated 10/18/73

Summary of Work - During September 1973, Abrahamson and Loomis spoke with officials of the Texas Department of Air Pollution, Texas Agricultural Extension Service of Texas, A&M University, and Texas Forest Service. The purposes of the trip were 1) to explain various Environmental Protection and Improvement Unit Programs, especially those programs dealing with air pollution and pesticides; 2) to establish lines of communication with the State Groups; and 3) to encourage cooperative work with the Environmental Protection and Improvement Unit.

In May 1974, Mason, Weiss, and Loomis examined an area of loblolly pine near an air pollution source in Liberty County. What may have

been some localized air pollution effects were noted on sweetgum, loblolly pine, and grape. Previous herbicide use in the area complicated symptom evaluation. The problem of concern on pine was observed over a wide area and was apparently not caused by air pollution.

Future work - The possibility of participating in a cooperative survey in FY 76 is being explored. Provide technical assistance as needed.

VIRGINIA

Contacts - Virginia Division of Forestry
Caleb L. Morris, Pathologist

Virginia Polytechnic Institute and State University
Department of Plant Pathology and Physiology
Dr. John M. Skelly, Associate Professor

Summary of Work - In March 1974, Loomis and Sites discussed the Air Pollution Program with Morris and Skelly while attending an Air Pollution Workshop at Virginia Polytechnic Institute. Morris mentioned that his organization is involved with air pollution effects on forest vegetation and maintains contact with the State Air Pollution Control Organization. Skelly heads up the Virginia Polytechnic Institute Air Pollution Program and would welcome cooperative studies or projects.

Future Work - Explore opportunities for cooperative work. Visit Skelly and Morris to learn more about their current air pollution programs.

Other Federal Contacts

TENNESSEE VALLEY AUTHORITY

Contacts - Dr. James A. Oppold, Acting Director of Environmental Planning
Dr. Herbert C. Jones, Supervisor, Air Pollution Effects Section
Dr. Sandy McLaughlin, Air Pollution Biologist
Niles T. Lee, Air Pollution Biologist
Ralph Cunningham, Air Pollution Biologist
Fred S. Bollin, Forester
John Blackwell, Engineer

Reference - Loomis' 7400 memo, dated 8/15/73
Yasinski's 1360 memo, dated 3/18/74
Phelps' 1360 memo (2), dated 4/10/74
Thompson's 3400 memo, dated 7/2/74
Loomis' 1360 memo, dated 7/25/74

Summary of Work - In August 1973, Loomis, Phelps, and Honing, met with Jones, Lee, Blackwell, and Bollin in Muscle Shoals, Alabama. The purposes of the trip were to learn more about the TVA Monitoring and Surveillance Programs, and to discuss Forest Service responsibilities and programs. Later, examples of SO_2 injury were examined in Walker County, Alabama.

In May 1974, Loomis and Yasinski met with Oppold, Jones, and Bollin in Chattanooga to discuss Forest Service and TVA responsibilities with regard to air pollution effects on the forest resource. When TVA facilities are involved, it was agreed that cooperative surveys would be desireable.

During June and July 1974, Mark Matuszewski, Kentucky Division of Forestry; Sites; Jones; Cunningham; and Loomis participated in cooperative air pollution surveys in Muhlenberg and McCraken Counties, Kentucky.

Also in July, 1974, Dugar, Sites, Weiss, and Loomis met with TVA Air Pollution Biologists to participate in an effects surveillance survey in Walker County, Alabama. Among others, the following topics important to Forest Pest Management's program were discussed:

1. The TVA Effects Evaluation Procedure. This included background and philosophy, map preparation, route selection, detection procedure, data collection, and data summary.

2. Recognition of sulfur dioxide and fluoride symptoms on forest species.

3. Recognition of forest species which are sensitive to sulfur dioxide and fluorides. These species are important as bioindicators of air pollution effects and are valuable in the detection and delineation phases of air pollution surveys.

4. Recognition of subtle differences in air pollution-caused symptoms as they change with time. Symptoms were noted which were only a few hours old, as well as symptoms which were several weeks old. In several instances both old and new symptoms could be seen on the same plant.

ENVIRONMENTAL PROTECTION AGENCY

Contacts - EPA Region IV (Atlanta)
Tommie A. Gibbs, Regional Air Pollution Control Director
Tom Helms, Chief, Planning and Standards Branch
Doyle T. Brittain, Air Surveillance Section (Athens, Georgia)
Dr. Donald Gillette, Chief, Division of Economic Effects (Research Triangle Park, North Carolina)

EPA Region VI (Dallas)
Richard L. Hill, Director, Air and Water Programs Division
Eloy Lozano, Supervisory Engineer, Air Programs Section

Reference - Loomis' 7400 memo, dated 7/16/73
Honing's 1630 memo, dated 7/31/73
Honing's 1360 (7400) memo, dated 7/31/73
Honing's 1360 memo, dated 3/26/74

Summary of Work - In July 1973, Loomis and Honing met with Gibbs in Atlanta in order to discuss Environmental Protection and Improvement Unit Programs. Gibbs mentioned that generally Environmental Protection Agency Regions have limited expertise and manpower for evaluating air pollution effects to vegetation, and that he would welcome cooperative assistance.

Also in July 1973, Loomis and Honing met with Hill and Lozano in Dallas to discuss Environmental Protection and Improvement Unit Programs, and to offer cooperative assistance in effects evaluation on the forest resource.

In August 1973, Loomis met with Helms in Atlanta to further discuss our Air Pollution Program, and to offer assistance in effects evaluation. Helms mentioned again that Environmental Protection Agency Region IV has limited manpower for air pollution effects evaluation. He also offered to explore the possibility of sending a memorandum to all State Air Pollution Control Organizations in Environmental Protection Agency Region IV explaining the effects evaluation services which could be provided by State Forestry and Forest Service pathologists. No action was taken because this suggestion was somewhat premature.

During January 1974, Loomis, Phelps, and Dr. Charles Berry, U.S. Forest Service research pathologist met with Doyle Brittain in Athens, Georgia. Brittain supervises the Environmental Protection Agency Surveillance Section whose task is to assist States with particular monitoring problems. His Section has done monitoring in remote areas and it was agreed that cooperative participation might serve the needs of both organizations.

In March and September 1974, Loomis spoke with Gillette first at the Virginia Polytechnic Institute Effects Workshop and later at the EPA National Environmental Research Center at Research Triangle Park, North Carolina. Gillette has been involved with the various State surveys and the Stanford Research Insitute Studies which attempted to define the cost of air pollution effects to vegetation. He provided valuable information and references concerning air pollution effects to vegetation.

AGRICULTURAL RESEARCH SERVICE

Contacts - Dr. Walter W. Heck
Dr. Allen S. Heagle
Dr. Richard A. Reinert

Reference - Loomis' 7400 memo, dated 8/9/73
Phelps' 1360 memo, dated 4/10/74
Loomis' 1360 memo, dated 8/6/74

Summary of Work - In July 1973, Loomis and Honing met with Heagle to discuss the Environmental Protection and Improvement Unit air pollution program and to learn more about the cooperative air pollution program between the Agricultural Research Service and the North Carolina Agricultural Experiment Station.

During July 1974, Dugar, Sites, Weiss, and Loomis met with Heck in Raleigh to discuss the broad aspects of air pollution effects evaluation and to learn more about oxidant injury to plants. Part of the time was spent examining foliage, which in Heck's opinion had symptoms similar to those caused by oxidant pollution. Reinert and Heagle discussed some of their air pollution growth loss and dose/response research projects.

Other Air Pollution Related Activities

Training - October 29 - November 2, 1973 - (Loomis), EPA Training Course in Houston, Texas, "Atmospheric Sampling."

November 12-16, 1973 (Loomis), EPA Training Course at Research Triangle Park, North Carolina, "Air Pollution Meteorology."

March 4-6, 1974 (Sites and Loomis) - Virginia Polytechnic Institute and State University Workshop in Blacksburg, Virginia, "Air Pollution Effects on Plant Life."

July 8-12, 1974 (Dugar, Sites, Weiss, and Loomis) - Tennessee Valley Authority Field Survey Training, particularly for sulfur dioxide and fluorides, Muscle Shoals, Alabama.

July 29-31, 1974 (Dugar, Sites, Weiss, and Loomis) - Agricultural Research Service discussion and field trip concerning symptomatology of oxidant injury, Raleigh, North Carolina.

Meeting Participation -

October 1973 (Honing) - Presented paper, "Air Pollution Effects on the Forest Resource" at the Soil Conservation Society of America annual meeting, Hot Springs, Arkansas.

October 1973 (Loomis) - Presented paper, "New Mexico and Arizona Air Pollution Survey" at the 21st Western International Forest Disease Work Conference, Estes Park, Colorado.

October 1973 (Abrahamson, Phelps, and Loomis) - Participated in a University of Kentucky Forestry School Seminar, Lexington, Kentucky. Environmental Protection and Improvement Unit Organization and Forest Pest Management and Environmental Quality Evaluation Programs were discussed.

February 1974 (Honing) - Presented paper, "Air Pollution Effects on the Forest Resource" at the joint meeting of the Southeast Section, Soil Conservation Society of America; and the Association of Southern Agricultural Workers, Memphis, Tennessee.

February 1974 (Honing) - Participated in the Military Entomology Training Conference of the Armed Forces Pest Control Board, Fort Sam Houston, Texas.

May 1974 (Loomis) - Presented paper "Air Pollution, Trees, and Our Environment" at symposium "In Pursuit of Clean Air" North Georgia College, Dahlonega, Georgia.

Publications -

In cooperation with Bill Padgett, Northeastern Area, Loomis revised Southeastern Area "Air Pollution and Trees," and Northeastern Area "Air Pollution Damages Trees" into the East-wide "Air Pollution and Trees in the East." Publication currently in press.

Cordell, C.E., W.H. Sites, and E.H. Manchester. 1973. AIR POLLUTION DAMAGE TO SEED ORCHARD WHITE PINE IN WESTERN NORTH CAROLINA. USDA, Forest Service, Southeastern Area, State and Private Forestry, Report No. 74-1-9, 10 pp.

DISCUSSION AND SUMMARY

There is evidence which shows that air pollution is having a serious effect on the forest resource in several areas of the United States, particularly in California. After approximately one year's effort to define what the effects of air pollution are to the South's forest resource, the question remains only broadly defined. We do know that forests are being affected near point sources, and may be affected over wide areas as shown by survey estimates and the decline of sensitive white pines. Other forest species are also thought to be sensitive to air pollutants (28). Unless better air pollution control technology is developed, these effects may become more evident because of the "Energy Crisis" and the scarcity of clean fuels.

But what is the cost of air pollution effects? How great should be our concern? Viewed strictly from a known timber loss viewpoint, the dollar cost is small. However, there are other undetermined costs. Who can adequately place values on shifts in tree and plant composition in forest communities. What should our concern be for possible subtle stresses such as reduced photosynthetic or reproductive rate, predisposition to entomological or pathological problems, or direct disease induction (22, 17). Other costs which are difficult to gauge include losses to trees in parks, watersheds, urban areas, and along highways.

The task of assessing the total impact of air pollution on plant life will probably never be accomplished through independent, highly fragmented, short-term research and survey efforts. A highly integrated systems approach using many research and survey disciplines will be required to determine present air pollution impact and the future state of the forest resource (25).

The Forest Service, as cooperative custodian of southern forests, should maintain a viable air pollution detection and evaluation support program; at least until the present significance and probable future impact of air pollution has been more completely determined.

Summary of Accomplishment by Program Activity

1. Defining the current problem and encouraging cooperative detection and evaluation surveys.

a. State Forestry and State Air Pollution contacts were made in 12 States in order to discuss the Environmental Protection and Improvement Unit Program; to focus attention on possible effects to the forest resource; to stimulate interest in conducting cooperative detection and evaluation surveys; and to identify air pollution problem areas.

b. Contacts were made with Forest Service Research, the Environmental Protection Agency, the Agricultural Research Service, and the Tennessee Valley Authority.

2. Developing standard survey and evaluation procedures.

a. Detection and evaluation procedures were adapted from procedures used in other insect and disease surveys. Valuable suggestions were provided by individuals in various agencies, particularly those in the Agricultural Research Service, Raleigh, North Carolina; the Tennessee Valley Authority, Muscle Shoals, Alabama; and U.S. Forest Service Research, Athens, Georgia.

b. Several evaluation tools are being investigated. These include:

(1) Remote sensing techniques.

(2) Use of filtered chambers.

(3) Development of more efficient ground survey techniques.

3. Providing specialized technical assistance to State and other Federal Agencies.

a. Cooperative surveys were conducted in Kentucky and Mississippi.

b. Technical assistance was provided in Alabama, Arkansas, Kentucky, Mississippi, Louisiana, North Carolina, South Carolina, Tennessee, Georgia, and Texas. Some examples of air pollution injury noted in the course of our evaluation assistance are presented in Appendix 3.

c. Booklet "Air Pollution and Trees" was revised and is in the process of being reprinted. This booklet is designed to support State and Federal Environmental Programs.

d. Outside Air Pollution experts were identified who indicated they could assist should the need arise. They are:

(1) Dr. Charles R. Berry, USFS, Athens, Georgia
(2) Dr. Walter W. Heck, ARS, Raleigh, North Carolina
(3) Dr. Allen S. Heagle, ARS, Raleigh, North Carolina
(4) Dr. Herbert C. Jones, TVA, Muscle Shoals, Alabama

Future Work

1. Provide air pollution effects evaluation assistance as requested to State and other Federal organizations.

2. Conduct cooperative incidence surveys in Tennessee, Florida, Virginia, Georgia, Alabama, Texas, and Arkansas. These surveys

provide the opportunity to:

a. Learn more about State effects evaluation procedures and experience.

b. Open lines of communication among cooperating agencies.

c. Provide evaluation training as desired.

d. Become more familiar with State air pollution problem areas.

3. Improve present evaluation techniques. This includes:

a. Survey work plan modification.
b. Evaluation chamber adaptation.
c. Aerial photography use.
d. Oxidant effects evaluation.

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APPENDIX

APPENDIX 1

STATES AND COUNTIES IN THE SOUTHEASTERN AREA WHERE TREES MAY BE SUBJECT TO AIR POLLUTION EFFECTS

APPENDIX 1 - States and Counties in the Southeastern Area where Trees may be Subject to Air Pollution Effects

State and County	Type of Pollutant			
	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
ALABAMA				
Baldwin	X			
Colbert*	X		X	
Calhoun		X		X
Dale			X	
Elmore	X			
Etowah	X			
Houston*			X	
Jackson*		X		
Jefferson	X		X	
Lauderdale			X	
Limestone	X			
Madison	X			
Marengo*	X			
Mobile	X	X	X	
Montgomery	X			
Russell	X			
Shelby	X			
Tuscaloosa	X			
Walker	X			
ARKANSAS				
Clark			X	
Crawford	X			
Crittenden	X			
Garland				X
Hot Springs*			X	
Jefferson*	X	Future X		

*Denotes trees examined

Appendix 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
ARKANSAS				
Phillips	X		X	
Pulaski*	X			X
Saline	X		X	
Sebastian	X			
FLORIDA				
Alachua	X			
Broward	X		X	
Dade	X			
Duval	X			
Escambia	X			
Hamilton			X	
Hillsborough	X		X	
Leon	X			
Manatee			X	
Orange	X			
Palm Beach	X			
Pinellas	X		X	
Polk	X			
Putnam	X			
Santa Rosa	X			
Seminole	X			
GEORGIA				
Bibb	X			
Chatham	X			
Chattahoochee	X			
Clayton	X			
Cobb	X			
DeKalb	X			
Dougherty	X	X		
Fannin		X		

*Denotes trees examined

Appendix 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
GEORGIA				
Fulton	X			
Gwinnett	X			
Houston	X			
Muscogee	X			
Richmond	X			
Walker	X			
KENTUCKY				
Boone	X			
Boyd*	X			X
Campbell	X			
Daviess*	X		X	
Fayette	X			
Henderson	X			
Jefferson	X			
Kenton	X			
Lawrence		X		
McCracken*		X	X	
Muhlenberg*		X		
Pulaski*		X		
LOUISIANA				
Ascension			X	
Bossier	X			
Caddo	X			
Calcasieu*	X			X
East Baton Rouge	X			
Iberville			X	
Jefferson	X			
Lafayette	X			
Ouachita	X			
Orleans	X			

*Denotes trees examined

APPENDIX 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
LOUISIANA				
Plaquemines			X	
Rapides	X	X		
St. Barnard	X			
St. Charles			X	
St. James			X	
St. Tammany	X			
MISSISSIPPI				
Clarke*				X
Harrison*	X	X		X
Hinds	X			
Jackson*			X	
Jones*				X
Lamar*				X
Rankin	X			
NORTH CAROLINA				
Beaufort			X	
Brunswick	X			
Buncome*	X			
Cherokee*	X			X
Cumberland	X			
Durham	X			
Forsyth	X			
Gaston		X		
Guilford	X			
Henderson*	X			X
Mecklenberg	X			
New Hanover	X			
Orange	X			
Randolph	X			
Richmond			X	
Union	X			

*Denotes trees examined

APPENDIX 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
NORTH CAROLINA				
Wake	X			X
Yadkin	X			
OKLAHOMA				
Canadian	X			
Cleveland	X			
Comanche	X			
Creek	X			
Kay		X		
LeFlore	X			
Oklahoma	X			
Osage	X	X		
Sequoyah	X			
Stephens	X		X	
Tulsa	X			
SOUTH CAROLINA				
Aiken*	X			X
Berkeley	X			
Charleston	X		X	
Greenville	X			
Kershaw*				X
Lexington	X			
Marlboro			X	
Pickens	X			
Richland	X			
Spartanburg*				X
TENNESSEE				
Anderson	X			
Blount	X		X	
Davidson	X			
Hamilton*	X			X

*Denotes trees examined

APPENDIX 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
TENNESSEE				
Knox	X			
Maury			X	
Polk*		X		
Shelby	X			
Sumner	X			
Washington	X			
Wilson	X			
TEXAS				
Aransas			X	
Bexar	X			
Bowie	X			
Brazoria	X			
Brazos	X			
Cameron	X			
Collin	X			
Dallas	X			
Denton	X			
Ector	X			
Ellis	X			
El Paso	X	X		
Fort Bend	X			
Galveston	X		X	
Grayson	X			
Guadalupe	X		X	
Hale			X	
Harris	X	X		
Hidalgo	X			
Hutchinson		X		
Jefferson	X			
Johnson	X			
Jones	X			

*Denotes trees examined

APPENDIX 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
TEXAS				
Kaufman	X			
Liberty*	X			X
Lubbock	X			
Marion	X			
McLennan	X			
Midland	X			
Montgomery	X			
Navarro			X	
Nueces	X	X	X	
Orange	X			
Potter	X	X		
Randall	X			
Refugio	X			
Rockwell	X			
San Patricio	X			
Smith	X			
Tarrant	X			
Taylor	X			
Terry			X	
Tom Green	X			
Travis	X			
Webb	X			
Wichita	X			
Winkler	X			
VIRGINIA				
Arlington	X			
Amherst	X			
Campbell	X			
Chesapeake	X			
Chesterfield	X			
Dinwiddie	X			

*Denotes trees examined

APPENDIX 1 (Continued)

State and County	Oxidant	Sulfur Dioxide	Fluoride	Unknown or Other
VIRGINIA				
Fairfax	X			
Fluvanna	X			
Hanover	X			
Henrico	X			
Loudoun	X			
Nansemond	X			
Norfolk	X			
Northampton	X			
Prince George	X			
Prince William	X			
Roanoke*	X	X		X
York	X			

*Denotes trees examined

APPENDIX 2

AN EVALUATION OF AIR POLLUTION EFFECTS TO TREES IN URBAN AND FOREST AREAS KENTUCKY, TENNESSEE, MISSISSIPPI - 1974-75

WORK PLAN

APPENDIX 2 - Work Plan
An Evaluation of Air Pollution Effects to Trees in Urban and Forest Areas
Kentucky, Tennessee, Mississippi - 1974-75

Introduction

Air pollution has caused injury to forest vegetation near large industrial sources (point sources). Perhaps more importantly, photochemical pollutants from urban areas (area sources) have caused decline of forests and crops far from urban centers. For example, tree mortality has been reported in California 80-100 miles from Los Angeles. In the East, reports of tree and crop injury from both point sources and area sources have been made. Thus, in view of the current energy crisis and resulting demand for the relaxation of air quality standards, it is important to: (1) identify major point and area sources of air pollution, and (2) examine trees in forest and urban areas in the vicinity of these sources. Two purposes of this examination are to help define where air pollution is affecting trees, and to gather baseline information which can be used in future evaluations should present air pollution levels change.

Objective

The broad objective in evaluating the effects of air pollution on vegetation is to determine what the present and future impact of air pollution on the forest resource may be. This work plan covers the first steps of such an evaluation. The objectives are:

1. To identify areas which may be affected by air pollution.

2. To evaluate forest and tree conditions in the vicinity of a representative number of these areas.

Methods

Source identification is best done in cooperation with the State Air Pollution Control Organization and with the Environmental Protection Agency. In most cases, these agencies maintain records of air pollution sources and the types of pollutant emitted. In addition, they have information as to availability of air quality data or equipment. Thus, Objective One is best accomplished by a cooperative review of these air pollution records by U.S. Forest Service plant pathologists, State Forestry Pest Management personnel, and appropriate scientists from the State Air Pollution Control Agency. If additional information is needed, the Environmental Protection Agency can also be consulted.

Objective Two is essentially a detection survey to better identify if or where air pollution affects plants. Should areas of particular

interest be identified, then a more intensive evaluation can be made at a later time.

The survey procedure will involve travel to the selected area, and an examination of trees and other vegetation in the vicinity of the source(s). The evaluation procedure is as follows:

As the local road system permits, look for acute air pollution effects in the four cardinal directions up to 5 miles from the source. This procedure should be modified as local conditions dictate.

1. Note if no effects are detected.

2. If effects are noted, record data from at least three areas (variable size plots) within the affected area in order to describe the effects. Record the maximum distance from the source acute effects are noted. Information to be recorded at the plot locations (see attached data sheet) should include:

   (a) Direction and distance of plot from source.

   (b) Species which show or do not show symptoms.

   (c) Extent of injury - percent individuals affected and percent leaves or needles affected.

   (d) Insect or other disease problems.

   (e) Other significant contributing factors or observations.

   (f) Photographs of symptoms which are suspected to be air pollution caused, or which result from other causes but may be confused with air pollution symptoms.

Coordination

Forest Service plant pathologists in the Alexandria Field Office and the Asheville Field Office will coordinate survey procedures, equipment and travel schedule with the State forest pest management specialist. The State specialist will be requested to make necessary contact and coordination with State air pollution personnel. The State specialist will also provide appropriate contact or coordination with State and private individuals or concerns.

Time Involved

Kentucky - 3 weeks, June & July, 1974
Tennessee - 3 weeks, June & July, 1975
Mississippi - 1-2 weeks, July 1974

Personnel

William H. Sites - Asheville Field Office
Melvyn J. Weiss - Alexandria Field Office
Robert C. Loomis - Atlanta Area Office
Mark Matuszewski - Kentucky Division of Forestry
Bruce W. Kauffman - Tennessee Division of Forestry
Richard J. Collins - Mississippi Forestry Commission

Reports

1. Results will be summarized by U.S. Forest Service personnel in a letter to the State Forester and the Air Pollution Control Director as soon as possible after completion of the survey.

2. A more complete report will be prepared by U.S. Forest Service personnel in cooperation with the State forest pest management specialist as soon as time permits.

Follow-Up Work

Based on information from this survey and on the needs of the State Forestry organization, it may be desirable to reexamine, at a later time, some of the areas included in the survey. In addition, other areas may become important, particularly those affected by area sources.

In order to adequately conduct or support air pollution effects evaluation, Forest Service pathologists are working to --

-- develop a team approach in evaluating difficult problems which may include both Forest Pathologists and Air Pollution scientists expert in various phases of air pollution evaluation.

-- develop capability of evaluating area source problems.

-- develop a lending bank of indicator plants.

-- explore use of remote sensing techniques.

-- develop field exposure chamber capabilities.

-- determine the relationship of observed air pollution effects and actual damage.

DETECTION SURVEY - AIR POLLUTION EFFECTS

State_____
County_____
Source_____
Date_____
Examiner_____

Distance from Source_____
Direction from Source_____

PLOT NUMBER_____

Plant Species	Uninjured Total	Injured Total	Effects* Rating	Sample Roll & Photo No.	Number	Remarks

*5/1 5 = Actual Percent Plants with Symptoms - If more than 20 estimate percent
1 = Estimated Average Leaf Symptom C[illegible]ss

5% = 1
6 - 20% = 2
21 - 50% = 3
51 -100% = 4

SUPPLEMENTARY INFORMATION

1. Past History
2. Topography
3. Forest Type
4. Meteorological Conditions
5. Known Dispersion Patterns
6. Pollutant (s)
7. Name and Telephone Number of Local Contacts
8. Supporting Diagnostic Symptoms or Abnormalities
9. Other

APPENDIX 3

EXAMPLES OF FOLIAGE SYMPTOMS NOTED WHILE EVALUATING AIR POLLUTION EFFECTS ON TREES IN FOREST STANDS AND URBAN AREAS

Suspected sulfur dioxide effects on yellow-poplar. Noted May 1974, Polk County, Tennessee

Suspected sulfur dioxide effects on hickory. Noted May 1974, Polk County, Tennessee

Suspected fluoride effects on redbud. Noted June 1974, Houston County, Alabama.

Suspected fluoride effects on loblolly pine. Noted June 1974, Marengo County, Alabama.

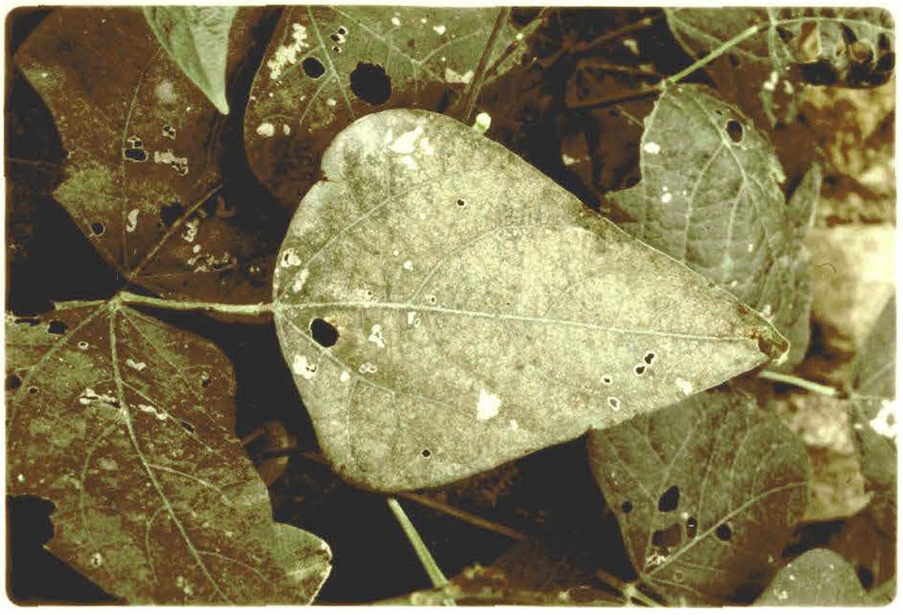
Effects on loblolly pine which have been subject to hydrogen sulfide and sulfur dioxide emissions. Noted July 1974, Clarke County, Mississippi.

Close-up of the loblolly pine effects noted above.

Effects on sweet gum which have been subject to hydrogen sulfide and sulfur dioxide emissions. Noted July 1974, Clarke County, Mississippi.

Effects on blackjack oak which have been subject to hydrogen sulfide and sulfur dioxide emissions. Noted July 1974, Lamar County, Mississippi.

Symptoms on mulberry which resemble those caused by oxidant pollution. Noted July 1974, Wake County, North Carolina.



Symptoms on bean foliage which resemble those caused by oxidant pollution. Noted July 1974, Wake County, North Carolina.

Aerial photograph showing suspected oxidant effects on white pine. Noted August 1974, Henderson County, North Carolina.

Suspected oxidant effects to white pine. Noted August 1973, Cherokee County, North Carolina